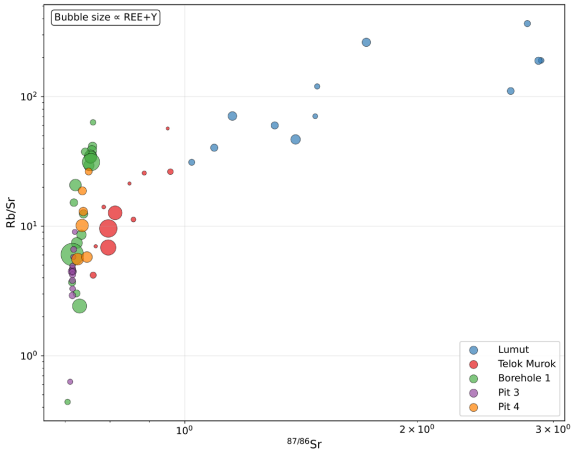
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# Controls on REE Enrichment in Tropical Regolith: Insights from Sr Isotopes and Elemental Ratios

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Tropical weathering strongly modifies the mineralogical and geochemical composition of rocks, driving element-specific mobilization, depletion, or enrichment within the regolith. In some cases, such processes generate economically significant supergene deposits, including regolith-hosted rare earth element (REE) accumulations formed through several mechanisms, particularly adsorption onto secondary clay minerals. However, the weathering conditions controlling REE fixation versus loss remain actively debated. Radiogenic strontium isotopes, coupled with elemental ratios, can provide robust tracers of fluid-rock interaction and weathering intensity.

Here, we present bulk elemental compositions and 87Sr/86Sr isotope data from five regolith profiles developed in two locations in Madagascar (Borehole 1, Pit3, and Pit 4) [1], and Malaysia (Lumut and Telok Murok) [2], both regions with potential for REE extraction. The Malaysian profiles, despite forming on similar granitic bedrock, display contrasting behavior: Telok Murok exhibits up to tenfold REE enrichment relative to its bedrock, whereas Lumut is REE-depleted. These differences are reflected in distinct trends in 87Sr/86Sr, Rb/Sr ratios, and REE+Y contents. The REE-poor Malaysian profile shows highly radiogenic Sr signatures and elevated Rb/Sr ratios, indicating extreme alkali depletion and intense leaching that likely prevents REE retention. In contrast, REE-enriched horizons correspond to intermediate weathering conditions where adsorption and fixation dominate.

The Madagascar profiles show less radiogenic bedrock and regolith compositions and smaller variations in 87Sr/86Sr along the profiles, although systematic changes in Rb/Sr distinguish profiles with different REE+Y contents. As previously shown by [2], the initial REE composition of the bedrock also plays an important role in controlling regolith REE enrichment.

Overall, our results demonstrate that coupled Sr elemental and isotopic systematics effectively track weathering regimes and provide a valuable framework for understanding the formation of regolith-hosted REE deposits.

References: [1] Estrade et al. (2019) Ore Geology Reviews, 112, 103027. [2] Yaraghi et al. (2020) Journal of Asian Earth Sciences, 199, 104385.